Challenges for the Heatshield Development of Sample Return Missions - An Overview on European Sample Return Studies and Requirements

Heiko Ritter
European Space Agency. European Space Research and Technology Centre
Netherlands

A. Santovincenzo
European Space Agency. European Space Research and Technology Centre

L. Walpot
AOES

The atmospheric entry of the Earth return capsule of sample return mission is one of the most critical phases of sample return missions. The Earth return from extraterrestrial bodies (e.g. Mars, comets or asteroids) involves a hyperbolic entry with entry velocities of typically above 12 km/s, resulting in peak heat fluxes in the order of 10 MW/m2 and heat loads up to 200 MJ/m2. While during a classical re-entry from Earth-orbit the heat flux is basically limited to convective fluxes, additionally radiative fluxes become increasingly important at entry velocities above 12 km/s.

In addition, since the Earth return capsule is subject to a "double" delta-V (to the object and back to Earth), the return capsule and its heatshield have to conform to a very stringent mass budget. Further, surface recession due to ablation and abrasion effects needs to remain limited in order to guarantee the aerodynamic stability.

This requires the availability of a highly efficient light-weight ablator material. In a dedicated study a screening of existing European ablators was performed to assess their suitability. Unfortunately, it turned out that none of the materials, which were developed in front of very different requirements, is suitable to sustain the very high heat fluxes while coping with the mass requirement. Dedicated development is therefore initiated to tailor materials towards the stringent requirements.

Another important aspect is the availability of plasma facilities for the qualification of the materials. Such high enthalpy facility needs to be able to reproduce the extreme heat fluxes at representative dynamic pressure levels and simulating the high radiation level. Additionally it would be beneficial to assess the dynamic stability of the entry capsule using free flight ballistic tests.

The paper will provide an overview on the main challenges involved in the development of the heatshield for the Earth re-entry capsule of sample return missions, resulting from different ESA

studies to Mars and asteroids. This will include system aspects, the choice of the TPS material and its qualification, flight path stability and reliability. Preliminary technology roadmaps will also be presented.